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Mortensen, K.; Scherer, G.G.; Gursel, S.A.

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Structural studies of polymer electrolytes for fuel cells in transport applications

Kell Mortensen,
Danish Polymer Centre, Risø National Laboratory, Roskilde, Denmark.

Günther G Scherer and Selmiye A Gursel,
General Energy Research, Paul Scherrer Institute, Villigen, Switzerland

A variety of the fuel cells under development are based a polymeric membranes that transport protons from the anode to the cathode. An example is the Nafion membrane from DuPont, which has been studied quite extensively. This membrane is a sulfonic-acid-based polymer system of perflourinated ionomers. In the search for alternative polymer membranes, radiation grafted systems have been proposed. Radiation Grafting offers a method to introduce functional properties into a preformed commodity polymer film. Grafting polymer membranes is an attractive method because a range of both base polymers and graft monomers are available at relative low cost. It is expected that it will be possibly to tailor specific materials parameters in attempts to optimize the membrane performance. These properties include ionic conductivity, mechanical strength, adhesion to other materials, and sensitivity to humidity and temperature. We have studied radiation-grafted polystyrene to matrices of flourinated ethylene propylene (FEP). The graft membrane is successively sulfonated to promote proton conductivity. We have further studied the effect of cross-linking. Thermal studies and x-ray scattering have shown that both the PS grafting and the sulfonation cause attractive increase in the amorphous fraction. We have extended the studies using small-angle neutron scattering. The SANS experiments show that the amorphous regions swell upon grafting with polystyrene. We observe a roughly 50% swelling when 20% PS is grafted and the membrane is cross-linked. Further amount of polystyrene have apparently only minor effect. Without cross-linking, however, the membrane gets inhomogeneous on a large length scale that may not be appropriate for optimal membrane properties.